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An Image Restoration Practical Method

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***Abstract*—This paper presents a frequency domain degraded image restoration practical method. We call it practical wiener filter. Using this filter, the value for K parameter of wiener filter is determined experimentally that is so difficult and time consuming. Furthermore, there is no any absolute remark to claim that the obtained images by restoration process are the best could be possible. In order to find a solution for this problem, we use genetic algorithm to obtain the best value for K. Therefore, this paper presents an image restoration method which employs a Computer Aided Design (CAD) to image restoration where there is no need to original safe image. It means that, degraded image is as input and restored one is as output of CAD. Simulation results confirm that this method is successful and has executive ability in most applications.**

***Index Terms*—Image restoration-degraded function-noise-genetic algorithm.**

I. Introduction

An image restoration technique is used to obtain a safe image from a degraded one. In most applications, it is impossible to obtain a completely safe image from degraded one, but often can minimize the distortion degree even sharpening the edges [1].The degradation of an image is caused by different degraders as improper camera setting, motion of camera and object, undesired reflected lights from uncontrollable sources, non-ideal photography and communication systems, atmospheric effects, blurring caused my motion, geometrical errors caused by improper lenses, white noise caused by hardware, etc. functionally, the degradation and noise patterns are not known. So we have to determine and estimate them experimentally [2].Some different spatially and frequency domains methods are used to restore a degraded image. According to need original safe image, most of these methods are not applicable practically where there is only degraded image. To solve this problem, this paper presents a practical method to restore a degraded image where there is no need to original safe image.

The structure of this paper is as follows: First estimation of degradation function is explained in section 2. Then estimation of noise pattern is explained in section 3 too. After that, some conventionally image restoration methods are reviewed in section 4. Finally proposed practically image restoration method is mentioned in section 5 and Simulation results are discussed in section 6.

II. Degradation Transform Function Estimation

According to Fig.1, f(m.n) is the original safe image, n(m,n) is additive white noise to the original safe image, h(m,n) is the impulse response function of linear time invariant degrader system, g(m.n) is degraded image and $\hat{f}$(m,n) is restored image. g(m.n) can formulize as:

$$g(m,n)=f(m,n)*h(m,n)+n(m,n) \tag{1}$$

There are three methods to estimate h(m,n), which are include of observation, experiment and using mathematics models as:

Observation: in this method, it is supposed that the original safe image is degraded by a linear spatial invariant function. If a proper high SNR sub-image to be chose and processed, degraded transform function of whole image (h(m,n)) will be extracted.

Experiment: there is possibility of obtaining a precise estimation of degraded transform function of image (h(m,n)), if we can reach to equipments that are similar to those are used to produce degraded image.

Mathematics models: in this method, it is tried to obtain the degraded transform function of image (h(m,n)) based on mathematically modeling effects of different degraded parameters. For example, the effect of environmental parameters as temperature and humidity are modeled as [3, 4]:

$$h(m,n)=e^{\frac{-(m^2+n^2)}{2\sigma^2}} \tag{2}$$

III. Noise Pattern Estimation

There are used some methods to determine noise pattern for a degraded image. Commonly used method is finding an image or sub-image contains only noise for using its histogram to find the noise pattern. Therefore we select a part of degraded image that is included of the known histogram. This part can be a sub-image from fixed part of original safe image. Then we use this known histogram to obtain noise pattern [5].

IV. Image Restoration Methods

The image restoration methods are categorized by different views. According to operation domain, they can be categorized as spatial and frequency domains. Also they can be categorized into iterative and non-iterative methods.

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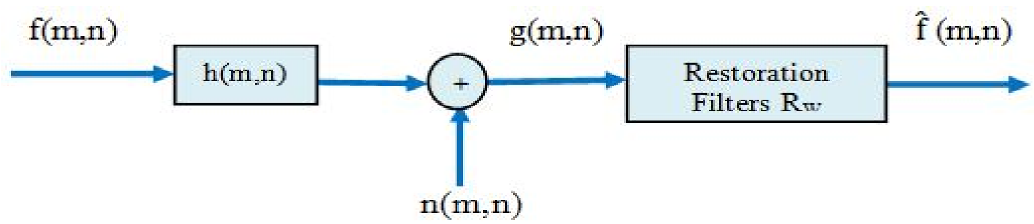

Figure 1.A view of degrader and restoration system [1]

According to our proposed method, follow we will briefly explain non-iterative restoration methods in frequency domain. In these methods, there is supposed white Gaussian noise as a stationary signal. These methods are as follows:

Inverse filter: This method is the simplest image restoration method. If the noise term is negligible, this method can be modeled as:

$$\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)} \tag{3}$$

Unfortunately, there are some problems to realize this filter. If $H(u,v)$ is equal to zero (or a very small value), there will be error of division by zero. Also if the noise term is not negligible, this image restoration method will not be applicable. So this filter has not practically enough usage.

Wiener filter: This filter is functionally utilized to minimize the mean square error between original safe image and restored one. The error term defines as:

$$e^2 = E\{(f-\hat{f})^2\} \tag{4}$$

Where E {.} means exception value. Natural problem effect of inverse filter is reduced by using wiener filter. This method is a statistical method using this assumption that image and noise have a zero mean Gaussian distribution. This filter is modeled as:

$$R_w(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \frac{S_n(u,v)}{S_f(u,v)}} \tag{5}$$

Where H*(u,v) is conjugate version of H(u,v), $S_n(u,v)$ and $S_f(u,v)$ are the power spectral of noise and original safe image respectively. Equation 4 will define inverse filter, when the noises term is negligible. When noise power spectrum increases, the denominator $\frac{S_n(u,v)}{S_f(u,v)}$ will increase, too. As a result, Rw will decrease. Hence the gain of this filter will decrease too. So we have an inverted filter in that parts of spectrum which have less uncleanness by noise. But the wiener filter enfeeble the signal in that parts of spectrum which largely destroyed by noise. The value of feebleness is determined by ratio of noise spectral to original safe image spectral. But because of this fact that there is no original safe image in hand to obtain its power spectral, this filter is not practically applicable.

Geometrical average filter: This filter is modeled as:

$$R_{GM}(u,v) = \left[\frac{H^*(u,v)}{|H(u,v)|^2}\right]^{\alpha} \left[\frac{H^*(u,v)}{|H(u,v)|^2 + \gamma\left(\frac{S_n(u,v)}{S_f(u,v)}\right)}\right]^{1-\alpha} \tag{6}$$

Where ϒ and ± are real and positive constants. When α =½and ϒ =1, it is called the power spectral equalizer filter. The geometry average filter will change to inverse and wiener filters, if α =½. This filter is called parametric wiener filter if α=0, as:

$$R_{pw}(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \gamma\left(\frac{S_n(u,v)}{S_f(u,v)}\right)} \tag{7}$$

But because of this fact that there is no original safe image in hand to obtain its power spectral, this filter is not practically applicable too.

Maximum probability filter: This filter is modeled as:

$$R_{MP}(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \left(\frac{R_n(u,v)}{R_f(u,v)}\right)} \tag{8}$$

Where $R_n(u,v)$ and $R_f(u,v)$ are autocorrelation functions of original safe image and noise term respectively. Equation 7 informs optimum wiener filter equation. But like other filters, there is no original safe image in hand to obtain autocorrelation functions. Hence this filter is not practically applicable too [1, 2, 3,4].

V. The Proposed Method

We explained practical methods to obtain noise and degraded function directly from degraded image in section 4. Then, different image restoration methods reviewed from practicable standpoint. The results proved that these methods are not practically applicable. Now we propose our practically applicable method which introduces a new version of wiener filter as:

$$R_w(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + K} \tag{9}$$

Where optimum value for K should obtain experimentally. We call it practically wiener filter. Of course we suppose noise term as a fix power spectral white Gaussian noise. According to equation 9, K parameter is a frequency-based function. It means that its value will increase, if frequency value to be increased and as a result gain of Rw(u,v) will decrease. Hence we can restore image where there is no need to original safe image. Experimentally optimum value obtaining for K parameter is difficult and time consuming. Furthermore, we cannot exactly claim that restored image is the best possible. To solve the problem, we use genetic algorithm to find the best possible optimum value for K parameter.

In this paper we presented a CAD to restore images which does not need to original safe images. It means that, degraded

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image is as input and restored one is as output of CAD (Fig.2). In fact this method is a non-iterative image restoration method in frequency domain which restores degraded image without need to original image (Of course this method can be considered as an iterative image restoration method in frequency domain, if we see it from the perspective genetic algorithm.). According to the discussions, we can consider the following steps for our proposed method:

1. Obtain degraded image as input.
2. Estimate degraded transform function of image.
3. Estimate noise pattern.
4. Use the genetic algorithm to find optimum value for K parameter.
5. Restore image using equation 9 for each iteration of genetic algorithm.
6. Use the subjective criteria to determine the best restored image.

To explain steps 4, 5 and 6, it is worth to mention that genetic algorithm is one of the strongest methods for researching which has low possibility of catching into local optimum points. We use binary single objective genetic algorithm that its flowchart shown in Fig.3. The important item is the way of definition of fitness function. We consider it as:

$$||n||^2=||g-H\hat{f}||^2 \qquad (10)$$

Where we should minimize above equation. Execute each iteration of genetic algorithm will produce a K parameter value which minimizes its fitness function. As a result, employing this K parameter value in equation 9, execute each iteration of genetic algorithm will produce a restored version of degraded image. Of course because of this fact that there is no original safe image in hand to determine the best restored image one using MSE, RMSE or PSNR criteria (objective criteria), we have to use subjective criteria.

VI.Simulation Results

We have utilized our proposed method for restoration of 100 different degraded images and obtained desirable results employing subjective criteria. Simulation results for our proposed method in comparison with non- practical wiener filter simulation results confirm effectiveness of it. The wiener filter restores a degraded image using power spectral of original safe image one. But there is no need to original safe version of degraded image in our proposed method. Simulations were done using MATLAB (Fig.4). The initial populations for genetic algorithm were considered 15 chromosomes that were coded with 8 bits. There was only one unknown parameter which was K parameter. The elitism ability was used to program the genetic algorithm. Simulation results showed effectiveness of the proposed method is image restoration issue. One of its merits is being automatic and fast that gives acceptable answer after 15 generations (it depends to researcher area). Restriction of this method is initial assumptions that exist for wiener filter, too.

Conclusions

In this paper, we proposed a practical method to restore a degraded image that it is called practical wiener filter. In this method a new parameter were considered for wiener filter which is obtained using genetic algorithm. It means that, this method is a powerful CAD to restore a degraded image which receives degraded image as input and gives restored one as output. Simulation results confirm the efficiency of this method in comparison with previous conventional methods.

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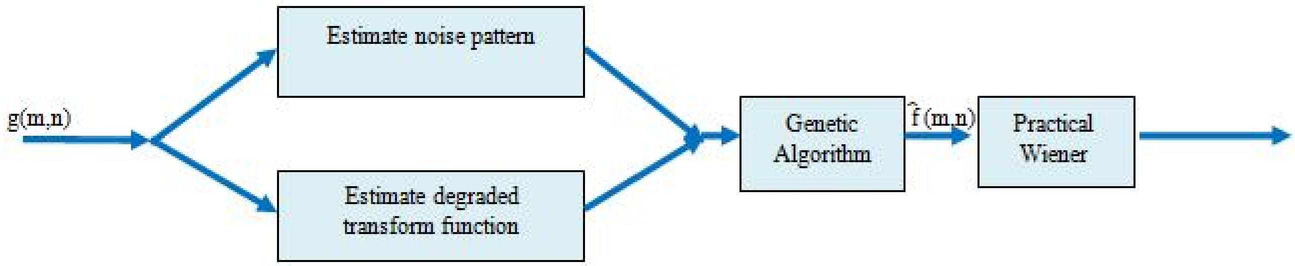

Figure 2.The suggested CAD

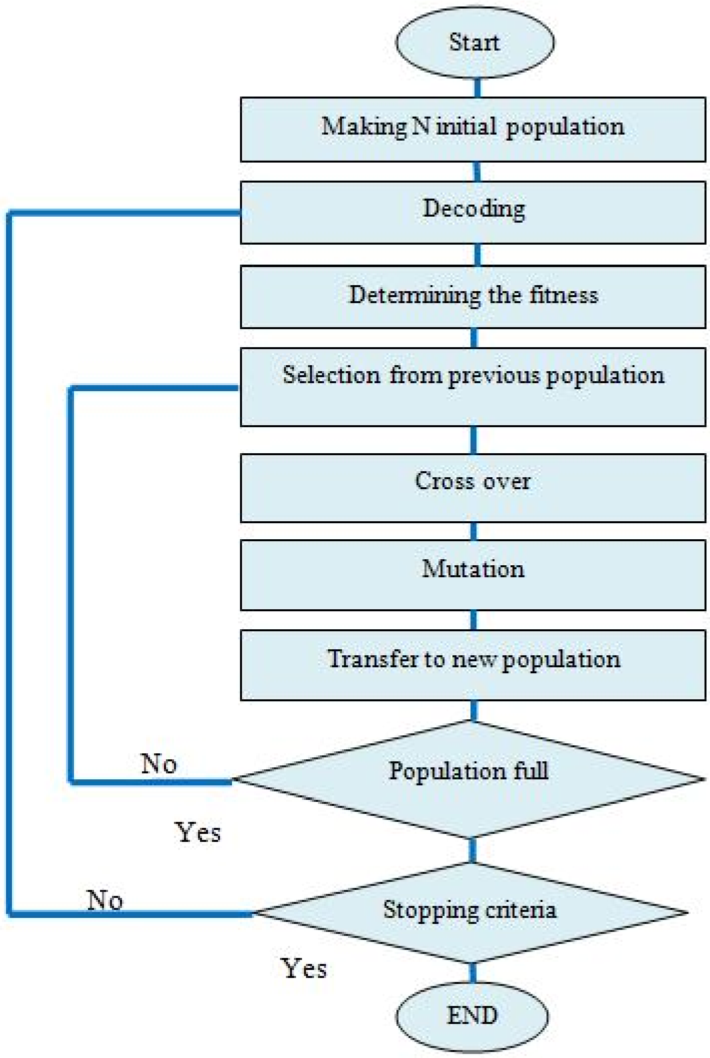

Figure3.Flow chart of implementation genetic algorithm [6]

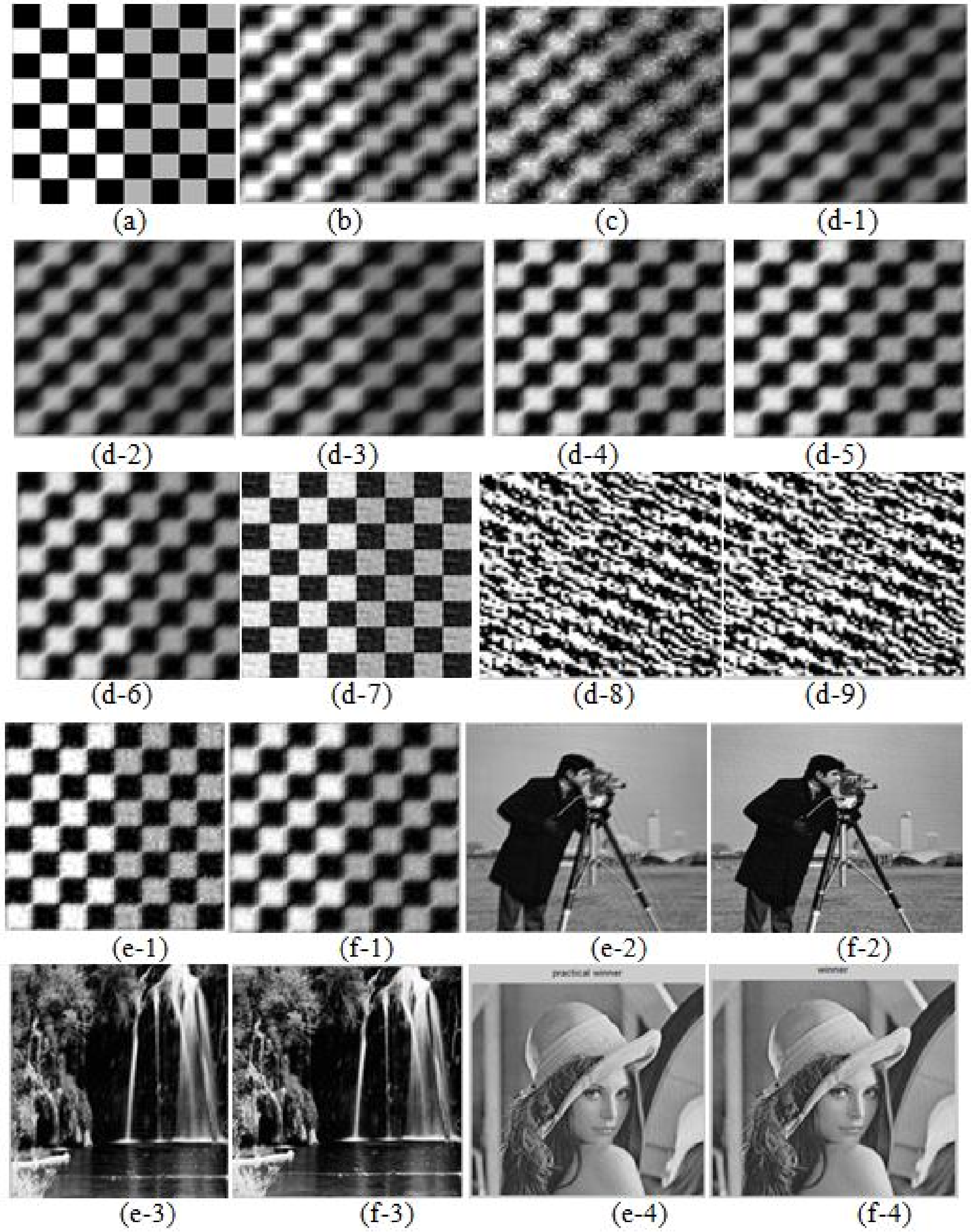

Figure 4.a) Original image. b) Degraded image with degradation function. c) Degraded image with degradation function and noise. d (1…9)) Process of restoration that gives ideal image after 7 times. e (1…4)) Restored image with suggested method. f(1…4)) Restored image with wiener filter

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